

# National Bureau of Standards

## TECHNICAL NEWS BULLETIN

VOLUME 35

NOVEMBER 1951

NUMBER 11

TECHNOLOGY

### Durability of Nylon

PUBLIC LIBRARY  
NOV 12 1951  
DETROIT

U593  
3LT1

An insight into the mechanism of the deterioration of nylons, also known as polyamides, has resulted from a recent extensive investigation conducted by B. G. Achhammer, F. W. Reinhart, and G. M. Kline of the NBS organic plastics laboratory. Thin films of the plastics were exposed to heat, ultraviolet radiation, and different types of atmospheres. The films were studied in various stages of degradation by a wide variety of techniques. It was thus possible to deduce some of the physical and chemical changes that had taken place. While the results obtained by NBS apply primarily to thin films of plastic-type nylon, they should provide a valuable basis for studies of the deterioration of other types of nylon in hosiery, textiles, brushes, and tires.

Improvement of the durability of plastic materials is one of the most urgent problems facing the plastics industry today. While the problem has been investigated extensively by means of accelerated tests involving one or more physical properties, empirical investigations of this type do not reveal the basic changes in the material and cannot be used to predict behavior in actual service. A complete understanding of the mechanism and kinetics of the fundamental reactions involved is needed. To provide such information, NBS is conducting a broad program of research on the degradation of plastics under the sponsorship of the Office of the Quartermaster General, Department of the Army.

The polyamides investigated by NBS were copolymers of nylon salts with  $\epsilon$ -caprolactam, having the repeated structure



Films 0.0001 to 0.0008 inch thick were exposed to heat, ultraviolet light, and various ambient atmospheres in apparatus specially designed to produce controlled degradation. They were also subjected to accelerated weathering and outdoor exposure tests.

In addition to analysis of the volatile degradation products with the mass spectrometer, both exposed and unexposed specimens were examined to obtain information concerning the changes in chemical and physical structure of the polymer. The techniques included infrared and ultraviolet absorption, measurement of viscosities of solutions, measurement of dielectric constant and dissipation factor, photomicrography, X-ray and electron diffraction, electron microscopy, and treatment with organic liquids. Pyrolysis studies were made to study the breakdown of the long polymeric chain at high temperatures. Some physical properties were also determined on specimens in various stages of deterioration. While no single method was found to give a complete picture of the nylon degradation, the results from several of the techniques in combina-

tion provide a valuable insight into the mechanism of the process.

These results show that the general course of the degradation of the polyamides studied involves three different types of changes. First, the polymer molecules break at the C—N bond of the peptide group, creating smaller polymer molecules with the same unit of chemical structure. The fragments broken out of the chain are evolved as carbon dioxide, carbon monoxide, water, and hydrocarbons. Second, changes in molecular orientation or crystallinity may occur as a result of changes in hydrogen bridging, hydrocarbon (CH<sub>2</sub>) packing, dipole rearrangement, and other secondary bonding among the polymer molecules. Third, the amount of strongly bound water and organic liquids such as ethanol may change. These materials, which act as plasticizers for the polyamides, are probably bound by hydrogen bridging to the oxygen molecule of the group. The changes in structure, molecular orientation, and chemically bound liquids produce marked changes in physical properties.

From the NBS investigation, it appears that the service life of polyamides could be extended by adding materials that would absorb ultraviolet radiation or by coating with a material that would keep the ultraviolet rays from the peptide group. Apparently it is unnecessary to protect against heat except under extraordinary circumstances.

Water and organic liquids act as volatile plasticizers. Thus, the water content of the plastic should be maintained at a relatively high value; however, excessive water absorption should be avoided because it results in loss of strength. Precautions should also be taken to prevent the loss of organic liquids, or, if they are lost, to make certain that they are replaced with water or some other material capable of forming a similar associated complex. Replacement of water and alcohols with less volatile water-insoluble materials bound to the polymer molecule in a similar fashion might provide a means of lengthening service life.

The detrimental effects of changes in crystallinity and orientation might be partially avoided by changing the chemical constitution of the polymer—for example, by alkyl-N-substitution. It appears, however, that as long as the carbonyl structure of the peptide group is present, a definite focal point of attack for degradation exists. If other groups, such as phenyl, were added, they might prevent deterioration by acting as radiant energy absorbers. However, they might also be capable of transferring their absorbed energy to the weaker C—N bond, causing it to break. Even if this happened, the resulting smaller polymer molecules would be prevented from crystallizing by the presence of the large side groups, and degradation would still be arrested to some extent. In view of the present limited knowledge of such effects, it is not possible to predict how much of the problem can be solved in this way.

For further technical details, see Mechanism of the degradation of polyamides, by Bernard G. Achhammer, Frank W. Reinhart, and Gordon M. Kline, *J. Research NBS* 46, 391 (1951) RP2210.



# TECHNICAL NEWS BULLETIN

U. S. DEPARTMENT OF COMMERCE

CHARLES SAWYER, *Secretary*

NATIONAL BUREAU OF STANDARDS

A. V. ASTIN, *Acting Director*

NOVEMBER 1951 Issued Monthly Vol. 35, No. 11

For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Subscription price, domestic, \$1.00 a year; foreign, \$1.35; single copy, 10 cents. The printing of this publication has been approved by the Director of the Bureau of the Budget, February 3, 1950.

## Contents

	Page
Durability of nylon	157
Ignition of fibrous materials by self-heating	159
Heater hum in amplifiers	160
A magnetic tape "memory" for SEAC	161
Corn sirup analysis by selective adsorption	163
Rating of water-current meters	164
NBS Antifreeze Tester	166
Wide-range decade frequency generator	167
Circuit printers for flat and cylindrical surfaces	168
NBS phosphorus-32 and iodine-131 solution standards	170
Society meetings	170
Illuminating engineering society	171
Statistical methods for chemists	171
Selection of hearing aids	171
NBS publications	172



A thin nylon film, held against a glass ring to prevent curling, is placed in an exposure chamber beneath the sun lamp. In operation the chamber is sealed with a Pyrex plate containing a Corex D window. Gaseous degradation products are collected in a separate trap.

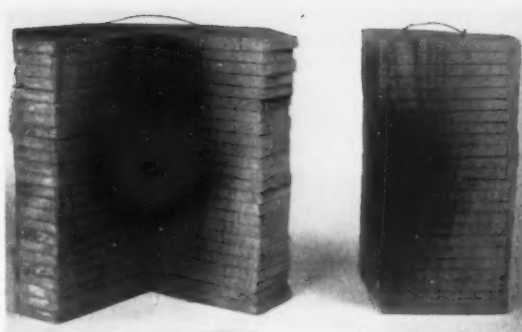
# Ignition of Fibrous Materials by Self-Heating

Recent investigations by the Bureau's fire protection laboratory have provided conclusive proof that closely packed fibrous materials can ignite by self-heating. NBS tests show that these materials in quantity, after standing for some time, may develop an internal temperature higher than the surrounding, or ambient, temperature. The extent of this temperature rise depends upon the material, its density and packing, and upon the ambient temperature and the length of time this state is maintained. This work thus gives strong evidence that suitable precautionary procedures should be taken in the storage and use of such commodities. For instance, a 12-inch cube of wood fiberboard kept at 147° F. develops a peak interior temperature of 148° F; a sample kept at 210° F develops a maximum internal temperature of 230° F; and a sample at 240° F develops a temperature of 305° F. If the size of the specimen is increased, the amount of self-heating is increased.

In general, the effect of self-heating is small; in some special cases, however, serious consequences may result if this effect is overlooked, particularly where materials packed in large stacks are involved. In one case, nine carloads of insulation fiberboard were shipped from a factory in the South, bound for New York State, before the heat of fabrication was completely dissipated. Seven days later one carload was discovered to be afire. The other eight cars when unloaded into an Army warehouse after 10 to 12 days on the road, were stacked in a single pile of more than 24,000 cubic feet. Four days later the warehouse and its contents were destroyed by fire, the loss amounting to 2½ million dollars.

During investigation of the cause of the fires, the possibility of ignition due to self-heating was considered. As a result, the Corps of Engineers asked the Bureau to investigate whether self-heating in the interior of wood fiberboard could be carried to such an extent as to cause the material to ignite.

A. C. Hutton and D. Gross, of the NBS Fire Protection Section, developed equipment and methods for studying self-heating characteristics over a wide range of size and temperature conditions. Boards cut octagonally were stacked in depths equal to the width of the octagon. These were introduced into a suitable oven or furnace and held at constant ambient temperature until the peak of self-heating was passed or until the self-heating had resulted in ignition. Series of increasing ambient temperatures were used until the

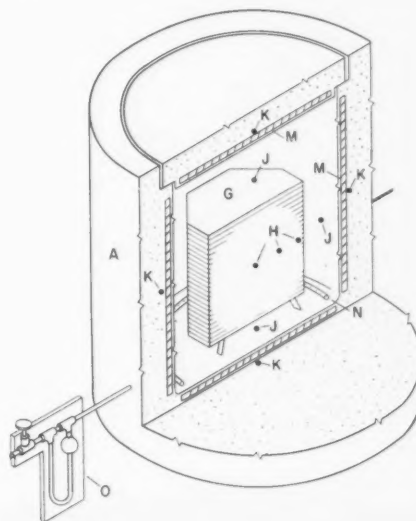


An octagon-shaped stack of fiberboards (cut apart after quenching) shows how ignition from self-heating starts at the geometrical center of the specimen and spreads outward. Controlled laboratory tests of fiberboard and similar materials have revealed that spontaneous ignition can occur under some storage conditions.

lowest ambient temperature at which ignition would occur was found.

The initial tests were made on wood fiberboard specimens 0.01 to 12 inches in diameter. The larger the volume of the specimen, the greater is the self-heating temperature rise within the specimen for a given ambient temperature and the lower is the external temperature required to initiate combustion. Ignition was found to start at the geometrical center of the specimen and spread outward through the remainder of the material.

Data were also obtained on cane fiberboards, felted cotton linters (alpha cellulose), Douglas fir, crushed coal, and alfalfa hay. For the cellulose-type materials so far tested, the lowest ambient temperatures that cause ignition fall within a range of 50 degrees F for a given sample size, but the times required to reach ignition vary widely. Thus, a 2-inch sample of wood



Controlled oven apparatus for studying spontaneous heating and ignition: A, oven; G, stacked octagonal test sample; H, sample thermocouples; J, oven temperature thermocouples; K, heating element thermocouples; M, heating elements; N, air distributing ring; O, air-flow control.

fiberboard at 356° F ignites in 18 minutes, while a 2-inch sample of felted cotton fiber ignites at 394° F after 63 hours. When the ambient temperature is allowed to rise with the self-heating of the specimen rather than being kept constant, ignition is accelerated.

For a given material, the logarithm of the ignition temperature was found to vary inversely as the logarithm of the specimen size. It appears probable that

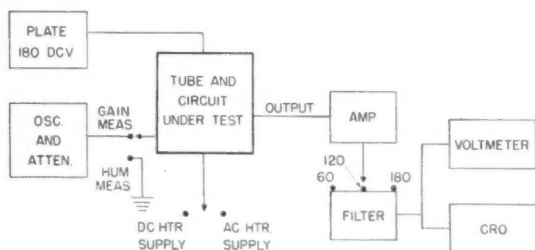
extremely large volumes of fibrous materials will ignite at relatively low ambient temperatures and that a potential fire hazard exists in the transportation and storage of these materials—in particular, immediately after hot processing and drying. More effective control of shipping and storing temperature and of stack size is therefore recommended to reduce the hazard of ignition due to self-heating.

## Heater Hum in Amplifiers

Heater-induced 60-cycle hum in alternating-current operated low-level amplifiers can be reduced to less than 1 microvolt by suitable choices of tubes and circuitry. Yet less fortunate tube-and-circuit combinations may give heater-hum levels of more than 500 microvolts. These are conclusions from a limited investigation of heater hum recently made at the Bureau's electronic instrumentation laboratory. Undertaken because of the need for low-hum amplifiers for instrumentation work at NBS, the study has yielded useful practical data for designing such amplifiers. Emphasis was on cataloguing heater-hum characteristics of various tubes and circuit arrangements, rather than on investigating the causes of the hum.

Eleven tube types, in various circuit arrangements, have been studied so far. Included were single triodes 6F5 and 6SF5; dual triodes 6SL7, 7F7, and 5691; and pentodes 6J7, 6J7G, 6J7GT, 6SJ7, 5693, and 6SH7. In general, only four to six tubes of each type were checked, although tubes of several manufacturers were included wherever possible. Data were discarded for occasional individual tubes which, because they showed wide deviations from the mean, were not believed representative.

Circuits were varied with respect to cathode bypass capacitance, heater-return tie point, heater-return potential, and grid-circuit resistance. The cathode resistor was either bypassed with a 50-microfarad capacitor or left unbypassed. Input grid resistance was either zero or 0.5 megohm. The heater return was either to one side of the heater, or through the adjustable arm of a 100-ohm potentiometer placed across the heater supply and adjusted for minimum 60-cycle output.



Block diagram of the complete measurement arrangement used for investigating heater-induced hum at the National Bureau of Standards.

Heater return potential was either to ground, to 45-volts positive, or to 45-volts negative. Hum measurements were made with various combinations of these circuit variations.

In the test set-up, the 60-, 120-, and 180-cycle hum components of the output of the amplifier under study were measured on a vacuum-tube voltmeter, using appropriate amplification and filtering. At the same time, wave form was observed on a cathode-ray oscilloscope. Gain was measured by applying a known signal to the grid of the test amplifier; hum level could then be expressed in terms of equivalent microvolts at the grid. Provision was made for switching from alternating- to direct-current heater supply for calibration and comparison.

To obtain the desired measurements of heater-induced hum, external alternating-current hum was reduced to a negligible value, using recognized shielding precautions; heater leads were twisted and shielded and kept away from the grid circuit, which was also shielded.

Circuit components were based on median values given in manufacturers' manuals. Preliminary checks indicated that hum is not significantly affected by the usual variations in components—plate, screen, and cathode resistors; and cathode and screen bypass capacitors—required to match different load impedances.

The most hum-free amplifiers investigated so far at NBS used either of several triodes (6F5, 6SF5, 7F7, or 5691) or a pentode (5693), in a circuit including bypassed cathode, heater grounded through an adjustable potentiometer, and low grid impedance. Wide hum differences were found for different tube types, as well as for different circuit arrangements. Apparently, however, the 60 cycle equivalent input hum of almost any tube type tested, whether triode or pentode, can be reduced to 10 microvolts by suitable circuitry; and all of the triodes tested could be brought below 2 microvolts.

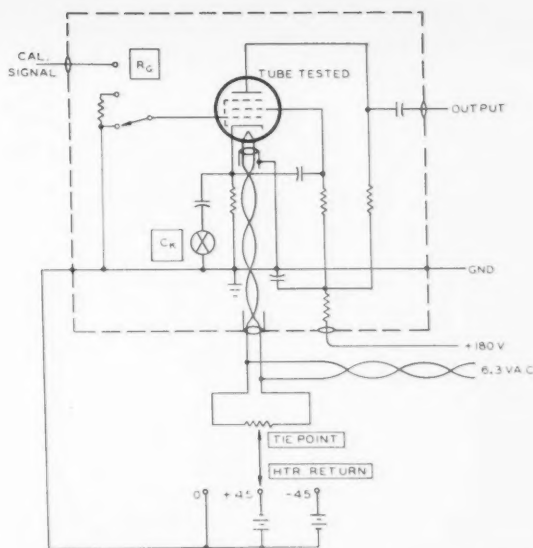
The NBS figures are for the 60-cycle components alone and are therefore not fully comparable with figures given in the literature, which generally include harmonics. The 60-cycle components were measured because of their importance in low-level power-frequency amplifiers, often required in instrumentation applications. Some of the low 60-cycle values measured at NBS were accompanied by harmonics no

Typical low-level amplifier circuit used in measurements of heater-induced hum. For each of a number of tubes, measurements were made with various conditions of grid circuit resistance, cathode bypass capacitance, and heater return. Both triodes and pentodes were investigated.

greater or even substantially less than the 60-cycle figure; in other instances the harmonics were many times greater than the 60-cycle component.

The general effects of the circuit variations were not unexpected. Without the cathode bypass condenser, hum was of course much greater; a sufficiently large bypass condenser is obviously desirable for all low-hum applications. Return of the heater circuit through an adjustable potentiometer connected across the heater supply, when adjustment was optimum, reduced the hum to as little as one-twentieth, or even one-fiftieth, of the initial value. Returning the heater circuit through 45 volts, either positive or negative but preferably positive, reduced hum somewhat in most cases. Increased grid circuit resistance tended to give greater hum in triodes, whereas in pentodes hum in general either showed no change or else decreased with increased resistance.

Various theoretical and practical aspects of heater hum have been treated in the literature. The NBS investigation, however, provides more practical data



than have been generally available on tube and circuit selection for minimizing heater hum in low-level amplifiers. The study of other tube types is planned.

## A Magnetic Tape "Memory" For SEAC

A computer-controlled external auxiliary "memory", using magnetic tape as the recording medium, is extending the problem-solving capacity of SEAC, the National Bureau of Standards Eastern Automatic Computer. Developed by James L. Pike of the NBS computer laboratory, the new magnetic tape memory unit combines high-speed starting, stopping, and reversing with notable mechanical simplicity. Two of the units are now in routine operation with SEAC, and plans call for adding two more.

In the new system, the magnetic tape rests lightly on two smooth-surfaced rollers that rotate continuously but in opposite directions. Between these two rollers the tape passes through magnetic heads for recording, pickup, and erasing. When either of two control solenoids is energized, a low-inertia rubber-covered roller presses the tape against one of the smooth rollers. This quickly starts the tape moving in the desired direction. Tape inertia is kept low by letting each end fall in loose folds into a tank or bin. Each tank consists of two plates of glass spaced just a little more than the width of the tape.

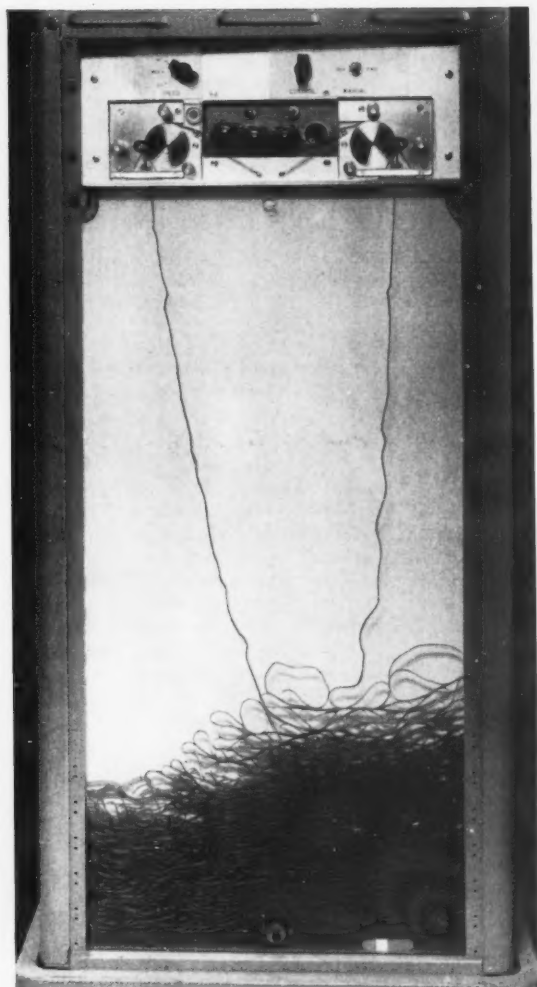
Dedicated in June 1950, SEAC was the first postwar automatically-sequenced super-speed computer to go into productive operation. The all-electronic machine was developed and constructed by the NBS staff under the sponsorship of the Department of the Air Force to provide a high-speed computing service for application of mathematical techniques to large-scale problems of military procurement and administration. For more

than a year now, SEAC has been actively turning out solutions to these and other important problems.

An electronic digital computer such as SEAC has a limited storage capacity in its internal high-speed memory, in which partial solutions are stored until needed later in the course of the solution of a problem. To handle many types of problems, it therefore becomes necessary to store information in an external memory; information is transmitted out of the computer for storage, and fed back in later in the problem. The speed with which this can be accomplished is a very important factor in the over-all operating speed. For instance, when Teletype tape was used with SEAC for auxiliary storage as a temporary expedient, reading the information onto the tape and back again often took more than 95 percent of the problem-solution time.

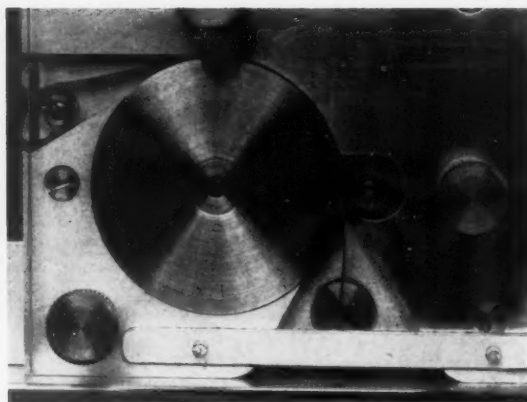
Thus far, the most promising method of reducing this time has been the use of magnetic recording. However, while computer-controlled auxiliary memory systems using magnetic pulses have been employed successfully in computers other than SEAC, most of these systems have required complex and expensive mechanisms to start, stop, and reverse the magnetic tape or wire with the necessary speed. The NBS magnetic tape memory has the advantage of combining speed, simplicity, and economy.

The speed and simplicity of the NBS system result from the successful elimination of reels and servo-mechanisms. Only two small masses need to be accelerated in starting the tape, the small jam roller and a few feet of tape hanging into the tank.



Although the tanks are large enough to hold several thousand feet of tape, an ordinary 1,200-foot spool is ample for most problems. The tanks are enclosed on all edges and have slots in the top for the tape to enter. Because the tanks are just wide enough to clear the tape, the loose folds in which the tape falls have no tendency to turn over or to become tangled.

Several problems have been encountered in developing the tape memory mechanism. For one thing, the tape tends to acquire an electrostatic charge as it passes through the drive mechanism. This can become quite troublesome at higher speeds, causing the tape to cling to the walls of the tank as soon as it leaves the drive mechanism. If the charge is strong enough, the tape may continue to stick at the top of the tank until it backs up into the mechanism and is damaged by a sharp fold. The present solution—satisfactory at moderate speeds (up to 8 feet per second)—is to ionize the air where the tape leaves the drive unit, using strips



In the magnetic-tape memory units that have been designed for SEAC, the tape rests lightly on two rollers that are driven continuously but in opposite directions (left and right of panel at top of complete unit; enlarged view, above). A corresponding jam roller (right, above) engages the tape against the larger roller when a solenoid is energized, quickly starting the tape in the desired direction. The tape then falls in loose folds into narrow glass tanks, each formed by spacing two glass plates just a little farther apart than the width of the tape. Electrostatic charges are eliminated from the tape by a strip of polonium (white bar, lower right, above). Between the two large rollers are the magnetic heads for recording, pickup, and erasing.

of alpha-emitting polonium. Another possible answer to the problem, though somewhat inconvenient, would be to control the humidity within the tanks. The ideal solution would probably be to make the base material of the tape sufficiently conductive so that a charge could not collect. Experiment indicates that base material having a resistance of not more than a few megohms per unit square should be satisfactory.

A second limitation on the operating speed of the tape is imposed by the need to erase information from the tape. The necessary erase frequency increases as the tape speed increases. A tape speed of 16 feet per second, for example, requires an erase frequency of several hundred kilocycles. Because of hysteresis losses, ordinary tape heads cannot operate at such high frequencies. New heads with powdered iron magnetic circuits, now being developed for use at much higher frequencies, should solve this problem. Meanwhile, it is always possible to erase the tape in a separate operation, at less than the normal running speed.

A third major problem in using magnetic recording in computer work is the presence of flaws in the magnetic tape. Commercially available tape has many small imperfections in the magnetic oxide coating, which are quite undetectable in ordinary audio work. In the recording of computer pulses, however, the loss of magnetic signals over a very small area in the tape may mean the loss of one or more digits of information. And in computer work the loss of a single digit—which may occupy less than 0.020 inch on the tape—cannot be tolerated. Some specially treated tapes now available are nearly free from flaws; and improved

manufacturing techniques may soon eliminate such difficulties. Meanwhile a process of removing the imperfections by scraping the recording surface over a suitably shaped knife-edge has been developed. This is somewhat laborious but is used as a temporary expedient. Another method of overcoming the flaw problem is to record from the back side of the tape through the plastic base. Although this allows only

about half as much information to be recorded in a given length of tape, the result is unaffected by flaws in the coating.

For other information on SEAC, see SEAC, the National Bureau of Standards Eastern Automatic Computer, *NBS Tech. News Bull.* **34**, 121 (Sept. 1950); also, SEAS demonstrates high reliability, *NBS Tech. News Bull.* **35**, 72 (May 1951).

## Corn Sirup Analysis by Selective Adsorption

A new procedure for the analysis of corn sirups, recently developed by Emma J. McDonald and Roger E. Perry, Jr., of the Bureau's organic chemistry laboratory, makes possible quicker and more accurate determinations of dextrose, maltose, and dextrin fractions. The NBS method makes use of the selective properties of certain carbon adsorbents [1]; after the mixed sirup has been adsorbed on a suitable carbon column, the several sugars can be removed selectively by three successive washings under pressure with water, 5-percent ethyl alcohol, and 15-percent ethyl alcohol. After the individual sugars are thus rapidly separated, each may be determined quantitatively by well-known methods.

The extensive use of sugar mixtures in food products has resulted in a growing demand for more rapid analytical methods, both in industry and in Government control laboratories. Present methods of corn sirup analysis are unsatisfactory both in the time required and in the accuracy of the results. The analyst has had to rely on a series of approximations based upon selective oxidation and fermentation reactions.

The apparatus required for the NBS separation method is quite simple. A glass column is filled with equal weights of the carbon adsorbent (Darco 60, analytical grade) and a diatomaceous earth filler (Celite). The top of the tube is coupled to a nitrogen tank, so that 30- to 50-pounds pressure can be applied to increase the rate of flow of liquid through the adsorbent.

The sample to be analyzed is added and allowed to penetrate the column. A 1-liter portion of water is then passed through under pressure. The water removes the dextrose but none of the maltose or dextrins. The washing is repeated, using this time a liter of 5-percent ethyl alcohol; this removes the maltose, leaving the dextrins. The dextrins are then removed with a liter of 15-percent ethyl alcohol. Finally, on completion of the run, the column is cleaned with 95-percent alcohol and then washed with water; this removes all traces of carbohydrates and leaves the apparatus ready for the next run. The whole separation can be accomplished in about 1½ hours.

Each of the three washings is then evaporated under diminished pressure to a volume that can be made up to 100 milliliters. The dextrose and maltose fractions are analyzed quantitatively either by polarization or by one of the accepted chemical procedures, such as Munson and Walker's reducing sugar method. The dextrin fraction, consisting of a mixture of polydextrose molecules, is reported in terms of its dextrose equivalent.

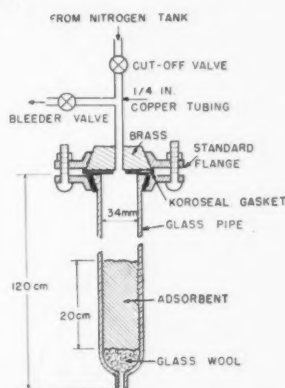
Reproducibility of the order of 1 percent in dextrose and maltose determinations is attainable with the NBS method. Most of the small uncertainty is the result of incomplete and slightly inconstant recovery from the carbon column. Recovery averages about 97 percent, experiments indicate, and varies with the particular column used. However, the incomplete recovery can be largely compensated for by experimentally establishing a correction factor for the particular installation. Once the sugars have been separated, accuracy of the order of 0.3 percent is attainable by chemical methods. Polarimetry tends to give somewhat less accurate results.

If the alcohol concentration of the washing solution is increased in several steps between 5 percent and 30 percent, the dextrins can be divided into triose, tetrose, and higher polysaccharides [2]. For most analytical purposes where time is important, however, it seems quite adequate to use the three-solution procedure and leave all the dextrins grouped together. Studies are continuing to extend the NBS method to include sucrose and invert sugar in sirups.

For further details of this new procedure, see A method for corn sirup analysis involving selective adsorption, by Emma J. McDonald and Roger E. Perry, Jr., *J. Research NBS* **47** (Nov. 1951) RP2263.

[1] These properties were described by R. L. Whistler and F. Durso, *J. Am. Chem. Soc.* **72**, 677 (1950).

[2] J. M. Bailey, W. J. Whelan, and S. Pent, *J. Chem. Soc.* (1950) 3692.



Dextrose, maltose, and dextrin fractions are conveniently and rapidly separated in the analysis of corn sirups by a new method of selective adsorption. Washing with water removes the dextrose from the adsorbent; 5-percent alcohol, the maltose; and 15-percent alcohol, the dextrins.

RECORDS of the flow of water in rivers and streams are important as bases for predicting future flow. Such predictions, in turn, have great economic importance. Extensive water-flow data have therefore been collected for many years by various governmental and private groups in the United States. For more than 3 decades, NBS has rated (calibrated) nearly all the water-current meters used in this country for measuring flow of rivers and streams, as well as many meters from foreign countries.

Calibration requirements for water-current meters have become greater each year, particularly in connection with reclamation, irrigation, flood control, and water-power projects. Demand for NBS calibration service has grown constantly, and about 1,200 meters are now rated annually by the NBS hydraulic laboratory.

In measuring the total flow of a river or stream, a properly calibrated meter is lowered into the stream and the water velocity measured at a number of points. By sounding for depth across the channel, the engineer can determine the cross-sectional area of the stream. The cross section is then divided into a number of subareas, and the flow through each subarea is computed from the average velocity through it. The flows through the various subareas are then added up to give the total flow.

Meters for stream gaging may be of either the propeller or turbine type. In either type the speed of the rotating element, measured by a counting device, depends on the velocity of the water flowing past it. An electrical contact mechanism does the counting in most



Water-current meters, almost all of them rated (calibrated) by NBS, are used in rivers and streams of the United States. Engineers of the U. S. Geological Survey are shown here operating a gage (not visible) on the James River near Richmond, Va. The gage (not visible) is lowered from the bridge.

## Rating of Water-Cur

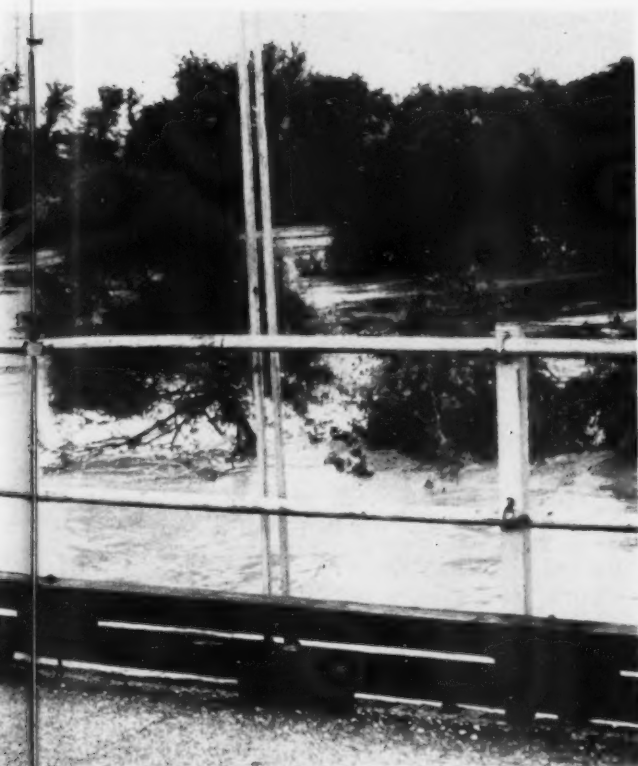
meters, while mechanically actuated recording counters are used in others.

Water-current meters are rated at NBS by towing them through still water at accurately known speeds and observing the resulting meter indication. In the NBS installation, the only one in the country generally available for this purpose, a railroad-type towing car rides above a still-water channel 400 feet long, 6 feet wide, and 6 feet deep. Running on carefully alined steel rails, the car carries its own electric motor. An oil-hydraulic speed-control system permits continuous speed change. Any speed from 0.05 to 14 miles per hour can be held substantially constant during a test run.

Many precautions must be taken to insure reliable results. For instance, great care is used to prevent bumps and vibrations in the motion of the car. Any vibration will be communicated to the meter and may

Water-current meters are calibrated at NBS by towing them at known speeds through a still-water channel, 400 feet long. The electrically driven towing car carries all necessary instrumentation.





D) NBS, are widely used for important measurements of water flow the U. S. Geological Survey are measuring flood waters on the James and from the bridge to controlled depths by the specially designed crane.

## Water-Current Meters

seriously affect its operation, particularly at low speeds. Although the wheels and the rails have been ground to a smooth finish, it has been found that any accumulation of dirt or rust will cause objectionable vibration of the car. Brushes are therefore mounted on the car to sweep the rails automatically.

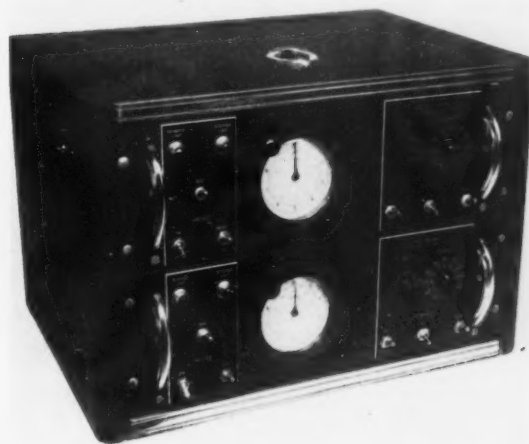
Meters are supported during calibration in a manner as nearly identical as possible to that which will be used in the field. This is desirable in order to avoid calibration errors, since experience has shown that the slightest change in the meter mounting yields a different rating curve. In the field, meters are either supported by vertical rods or are weighted and suspended from cables, depending on the depth of the stream. The NBS laboratory is therefore equipped with a complete set of both rod supports and cable suspensions.

Above: Electrical control equipment makes the calibrating runs largely automatic once the towing car has been brought to the desired speed. Below: A type of water current meter in widespread use.

In making a test run, the rating car is first brought up to the desired speed, as indicated by a stroboscopic disk. A signal from the meter then causes a dart to be shot into a distance scale alongside the water channel, and simultaneously starts a timer. After a predetermined number of revolutions of the meter, the electrical control mechanism automatically shoots another dart into the distance scale and stops the timer. The velocity and the number of revolutions per second can then be computed from the distance between the two dart positions, the time, and the number of revolutions of the meter. Plans call for simplifying the procedure slightly by measuring the distance with an automatic recorder geared to the nondriving wheels of the car, thus eliminating the darts.

When rating a meter at least six pairs of towing runs are made, each about 100 feet in length, at velocities representative of the range for which the meter is to be used. By making pairs of runs in opposite directions at the same speed, the effect of any currents in the tank is cancelled. An interval of about 5 minutes must be allowed between runs for the disturbances created in the water to subside.

Ratings are usually presented graphically for use in the field (revolutions per second plotted against velocities in feet per second). Although the rating curve of an ideal frictionless meter would be a single straight line, actual meters fall slightly short of the ideal. For practical purposes, however, sufficiently accurate results are usually given by two straight lines, one for lower and one for higher speeds. Greater accuracy may be obtained by computing rating equations from



the observed data, using automatic calculating machines.

High precision is realized in NBS water-meter ratings. Analysis of a large number of ratings indicates that the probable error of each observation even at low speeds

is only 0.5 percent and improves to 0.2 percent at higher velocities. This order of precision, high for hydraulic measurements, is more than adequate for the practical field uses to which the meters are put.

## NBS Antifreeze Tester

### A Practical Protection Indicator for Automotive Antifreezes

An easily constructed device recently developed by R. B. Rudy and J. I. Hoffman of the Bureau's surface chemistry laboratory makes it possible for service stations to make more reliable tests of automotive antifreeze solutions. Simple and rapid in application, the NBS Antifreeze Tester determines the "practical" freezing point, that is, the lowest temperature at which the solution will flow through a passage comparable in size to those found in an automobile radiator. Unlike the widely used hydrometer, the new device is applicable to all types of antifreeze solution or any mixtures of them now on the market.

Almost every motorist at some time during the winter driving season finds it necessary to reassure himself regarding the protection provided by the antifreeze in his automobile radiator. If the antifreeze solution contains only ethylene glycol or one of the common alcohols, a hydrometer will usually give sufficient accuracy for all practical purposes. Even so, minimum protection temperatures as determined by different service stations on these solutions sometimes differ by as much as 30 degrees. On the other hand, if the antifreeze solution contains propylene glycol, a mixture of gly-

cols, a mixture of alcohols, or any combination of these materials, the hydrometer becomes practically useless in determining its effectiveness. The NBS Antifreeze Tester was developed to meet the increasing need for a practical yet reasonably accurate method for determining the protection provided by all types of antifreezes in the shortest possible time.

The heart of the device is a brass cylinder having a passage 1.5 millimeters (0.06 inch) in diameter, through which the sample flows until, as its temperature is lowered, the formation of ice crystals blocks the passage. The sample is admitted to the passage in the cylinder from a reservoir that is made of a vertical glass tube open at the upper end, its lower end connected to the cylinder by means of a rubber stopper and a length of brass tubing. Flow of the liquid from the reservoir into the 1.5-millimeter passage is controlled by sliding a rod in and out of the hole in the rubber stopper.

The brass cylinder containing the test passage is cooled by inserting it into a brass tube that is soldered to a copper box filled with solid carbon dioxide ("dry ice"). Both the copper box and the attached tube are

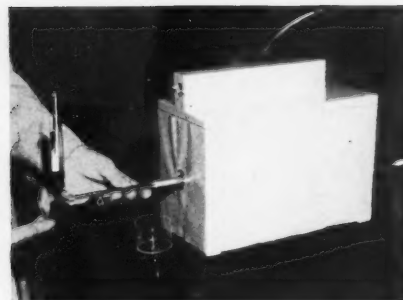


All types of automotive antifreezes can be tested simply and rapidly by means of the new NBS Antifreeze Tester.

(A) and (B)

Sample of antifreeze solution is removed from automobile radiator and (B) transferred to antifreeze tester.

(C)



Tester assembly is placed in freezing cabinet.

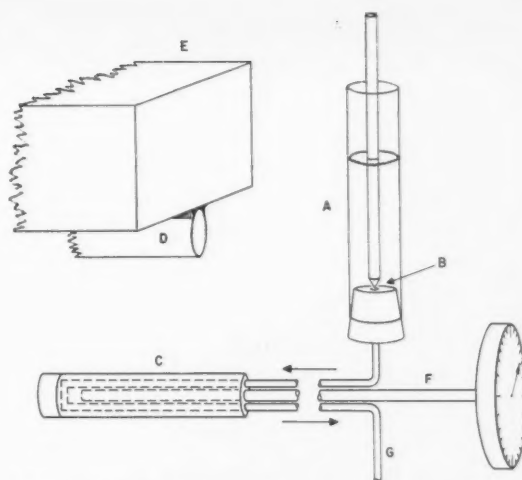
(D)

After removing from freezing cabinet, temperature at which second drop of fluid flows from exit tube is noted.

enclosed in a thermally insulated wooden box. The temperature of the cylinder is obtained from the dial of a bimetallic thermometer whose stem passes through the center of the cylinder. As the temperature rapidly falls below the freezing point of water, the valve in the reservoir is opened at about 10-degree intervals until no more liquid flows from the exit tube in the brass cylinder. The cylinder is then removed from the cold tube and promptly placed in a hole provided in the wooden cover of the insulated box. As the cylinder slowly warms, the exit tube is watched, and when the second drop of liquid falls, the temperature is read. This temperature is the lowest at which the liquid being tested will circulate through the passages in an automobile radiator.

The determination requires from 3 to 6 minutes, depending upon the freezing point of the solution. Approximately 2 pounds of dry ice will suffice to keep the device operating for 8 to 10 hours.

Tests were made at NBS on antifreeze solutions obtained from a number of car owners selected at random. The maximum difference between readings made on six of the solutions by three different operators using the new antifreeze testing device was 2 degrees F for a given solution, and the average spread was 1 degree F. The minimum protection temperatures found were usually slightly below the temperatures at which the various solutions first show formation of ice crystals. Estimates given by service stations for the protection



Schematic diagram of NBS antifreeze tester: A, glass reservoir; B, passage from reservoir to brass cylinder; C, D, cooling tube; E, box containing solid carbon dioxide; F, bimetallic thermometer; G, exit tube.

afforded by the solutions were found to vary as much as 30 degrees from the readings obtained with the NBS device. It is believed that an inexperienced operator using the NBS Antifreeze Tester should obtain protection temperatures that are reliable within  $\pm 2$  degrees F.

Automotive antifreezes have been a subject of investigation at NBS for many years. These studies, performed largely for other Government agencies, have included not only simulated and actual service tests of antifreezes but also basic investigations of the physical and chemical properties of antifreeze compounds and of the materials used in the cooling system of a car. As a result, NBS has been able to advise motorists on the proper use of antifreezes [1] and to warn them of the harmful and often dangerous effects of certain types of antifreezes.

[1] Practical information on this subject, in a form designed to be useful to the average automobile owner, is given in NBS Circular 474, *Automotive antifreezes*, available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., at 15 cents a copy.

Results of NBS tests of antifreezes

Type of antifreeze	Protection estimated by service station	Tester readings			Formation of first ice crystal
		Operator			
		A	B	C	
	$\pm F$	$\pm F$	$\pm F$	$\pm F$	$\pm F$
Mixed alcohols	+10	+6	+8	+7	+10
Methanol	+10	+13	.....	.....	.....
Do.	0	+4	+3	+5	+5
Do.	+5 to +10	+3	+3	+3	+4
Ethylene glycol	0	+18	.....	.....	.....
Do.	+5	+11	+11	+11	+13
Do.	-10	+11	+11	+11	+11
Do.	-30	-1	0	-2	-1
Do.	-6	.....	.....	-1	.....
Do.	-5	.....	.....	-1	.....
"Alcohol"	+10	.....	-11	-12	.....
Propylene glycol	+10	+13	.....	+13	+11
"Permanent"	+17	.....	.....	+12	.....

## Wide-Range Decade Frequency Generator

A decade frequency generator, developed by J. M. Shaull of the National Bureau of Standards, supplies separately filtered voltages at frequencies from 100 to 1,000 kilocycles in 100-kilocycle steps. The generator provides precise and easily identifiable marker frequencies that are ideally applicable to laboratory frequency measurements and calibrations. The circuit is so designed that all undesired harmonics and multiplier side frequencies are attenuated by more than 60

decibels; consequently the unit may also be employed to drive converters used in exploring high- $Q$  resonators such as quartz-crystal units.

The generator consists of limiting and pulse-shaping circuits, grid filters for separating the desired harmonics of 100 kilocycles, and 10 output amplifier stages. The output power of each stage is 0.1 watt at a nominal impedance of 100 ohms. Power consumption with all output stages operating is about 75 watts.

The plates of the tubes are coupled to the output connectors through tuned transformers, and each circuit is provided with a separate output control switch.

A power output of 0.1 watt at 100 ohms was chosen as having the greatest utility with a minimum of unfavorable design considerations. The 100-ohm impedance is in the range of most crystal mixers and connecting cables and at the same time develops sufficient voltage to drive the grids of multiplier or converter stages directly. This nominal output is easily obtained from a class A tuned amplifier with low power drain but still maintains a high plate tank  $Q$  with its additional attenuation of harmonics. Shielding and decoupling requirements also are much less severe at this low operating level.

The NBS decade frequency generator requires a 100-kilocycle input signal between 2 and 10 volts at about 100 ohms. This signal may be supplied from a standard-frequency generator or any other stable frequency source. The 100-kilocycle signal is shaped and amplified, and the pulse power, now composed of harmonics between 100 and 1,000 kilocycles, is supplied to a harmonic bus. The bus, in turn, supplies nine 6SK7 amplifying tubes through individual grid filters. The generator outputs are coupled to the amplifiers through plate coupling transformers designed to operate with a working  $Q$  of about one-half their unloaded  $Q$ . During normal operation, the output voltages into 100

ohms, with all outputs in use, range from 3.2 to 3.7 volts.

The built-in power supply is of conventional design, employing choke input with two stages of filtering. The alternating-current input is by-passed at the entrance point, and the filament and plate leads to the amplifier stages are also by-passed to reduce mutual coupling between stages or coupling to other units through the power line. Separate resistance-capacitance decoupling is also employed in the screen and plate leads of each amplifier stage. The unit should preferably be operated from a stable alternating-current source to minimize phase shift, which might cause a slight frequency modulation.

After the 27 tuned circuits of the NBS decade generator are properly aligned, further adjustment is seldom required. A wide-band oscilloscope is useful for observing the pulse wave form on the harmonic bus, and the ratios of the output stages may be determined by obtaining Lissajous figures.

An application of the decade frequency generator circuit is now being used in the NBS Microwave Frequency Standard, in which the same design principles are utilized to obtain 100-kilocycle steps between 2 and 3 megacycles.

*For further technical details, see Wide range decade frequency generator, by J. M. Shaul, Tele-Tech, 9, No. 11, 36 (Nov. 1950).*

## Circuit Printers for Flat and Cylindrical Surfaces

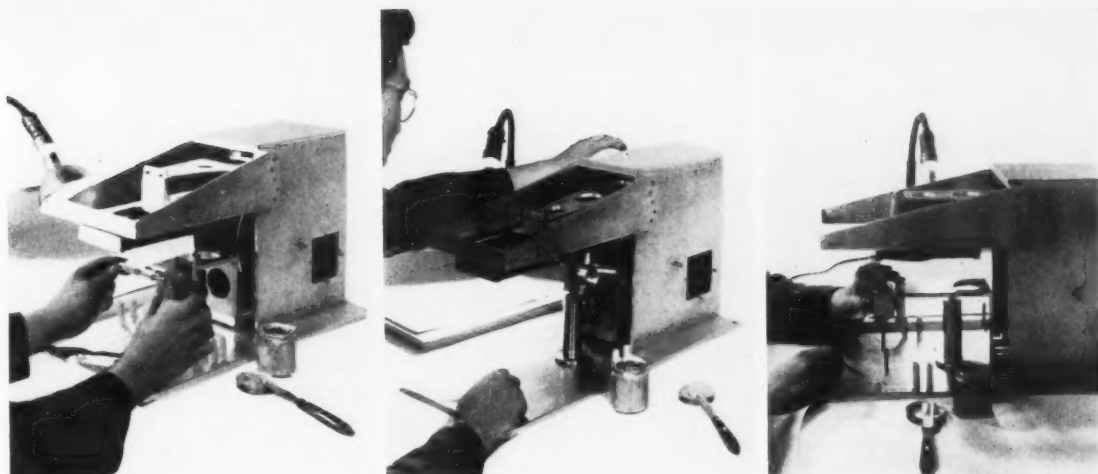
Two semi-automatic machines for printing electronic circuits, one for flat surfaces and the other for cylindrical surfaces, have recently been developed by Robert L. Henry and associates of the NBS engineering electronics laboratory. The new printers are products of a continuing program of printed circuit development sponsored by the Navy Bureau of Aeronautics. Although few if any automatic printers have hitherto been developed for printed circuit applications, such printers seem to offer two important advantages. First, they are faster than hand printers and more economical for use in quantity production. Second, and perhaps equally important, they give a more uniform product.

Printed circuits—in which wiring and components are superimposed directly on insulating bases—are being used increasingly because they can be economically produced in quantity and because they facilitate miniaturization of equipment. Circuits are usually printed manually by a stenciled-screen process in which a rubber squeegee forces silver paint onto the insulating base through openings in a fine silk or metal screen. Firing of the printed plates then drives off the paint vehicle and leaves an adherent silver film of high conductivity.

The NBS printer for flat plates is motor-driven and more fully automatic than the printer for cylindrical surfaces. In the flat-plate printer, a turntable accepts the unprinted plate at a loading position, carries it to a printing position, then carries the printed plate to



Ceramic plates are placed manually in the loading position on the automatic circuit printer for flat surfaces, moved to the rear of the machine where silver circuit patterns are impressed on them, carried to the unloading position (right), and then slipped into the discharge chute.



Three steps are followed in the operation of the NBS cylindrical-surface circuit printer. Left: A cylinder is loaded on the mandrel. Center: As the operator moves the control lever, the cylinder is raised against the stenciled screen, and the rubber squeegee (above) is simul-

taneously lowered; the screen moves over the cylinder, and silver paint is forced through the screen onto the cylinder in the desired pattern. Right: At the end of the printing stroke the mandrel automatically turns downward and the printed cylinder slips off.

an unloading position, where it is automatically flipped into a chute.

In regular operation, three plates are processed simultaneously: while the first plate is unloaded, the second is printed, and the third is loaded. The turntable stops while these operations are performed, advances the plates one-third of a revolution, stops again, and thus continues the sequence. The usual production rate, about 1,000 plates per hour, can be increased to 1,500 per hour without loss of printing quality but at the expense of excessive wear and tear on the machine.

As the turntable advances the plates from position to position, they rest on rectangular platens about 3 by 4 inches in size. These flat platens are normally flush with the turntable. However, when a plate-carrying platen reaches the printing position, the platen rises and presses the plate against the underside of the printing screen, which occupies a fixed horizontal position. While the plate is held against the screen, a rubber squeegee is automatically moved over the top surface of the printing screen, forcing conducting paint through the screen onto the plate in the desired pattern. The platen is then lowered to its flush-with-the-turntable position and is advanced by the turntable another third of a revolution to the unloading position. Here the platen is tilted, and the printed plate slides into the discharge chute.

The flat-surface printer is at present loaded by hand, one plate at a time, as the turntable moves the three platens past the loading position. Otherwise the process, including the flipping of the printed plates into the discharge chute, is entirely automatic. The loading of the unprinted plates, and also the carrying away of the printed plates, could be done automatically by conveyors.

The NBS cylindrical-surface printer was developed for the printing of cylindrical ceramic forms less than one-half inch in diameter. Such small ceramic cylinders are usually out-of-round and present a much more difficult printing problem than larger, more perfect forms.

The cylindrical-surface printer is loaded manually by slipping the cylinder to be printed over a mandrel. A single stroke of a hand-operated control lever then puts the machine through the entire printing cycle and operates a release mechanism, which drops off the printed cylinder.

This printer differs from a conventional printer in that the squeegee remains stationary. As the control lever is brought forward, the mandrel, bearing the cylinder to be printed, rises to meet the stenciled screen. Simultaneously the squeegee, which is directly above the mandrel, drops to press against the top surface of the screen. The screen, which remains flat and horizontal at all times, then starts to move (forward on one stroke, backward on the next) over the cylinder, and the cylinder rotates in response to the horizontal motion of the screen pressing against it. While the cylinder rolls against the screen, the squeegee forces conducting paint onto the cylinder through the pervious pattern of the screen. When the cylinder has made one complete revolution, both cylinder and squeegee are moved away from the screen. As the control lever is moved back to its starting position, the mandrel carrying the cylinder is rotated from a horizontal to a downward position, a release mechanism on the mandrel is actuated, and the printed cylinder drops off.

With hand loading of the cylindrical surface printer, an operator can easily print 1,500 cylinders in an 8-hour day. An automatic feed mechanism and electric drive, which could be added without much difficulty,

should increase the production rate to a probable 500 or 1,000 cylinders per hour. For fully automatic production at high speed, a conveyor belt system with steadying pins could also be added to carry away the printed cylinders.

*Additional data on NBS work in the field of printed circuits has been reported in NBS Circular C468, Printed circuit techniques, and NBS Miscellaneous Publication M192. New advances in printed circuits, which are available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., at 25 cents and 40 cents, respectively; and in OTS Report No. PB-100950, Printed circuits, available only from the Office of Technical Services, Department of Commerce, Washington 25, D. C., at \$1.75 a copy.*

## NBS Phosphorus-32 and Iodine-131 Solution Standards

The National Bureau of Standards has now added standard solutions of phosphorus-32 and iodine-131 to its list of Standard Samples available for general distribution to investigators in physics, chemistry, medicine, and industry. The program was initiated on a limited basis early in 1946 and is now expanded to operate on a periodic schedule.  $P^{32}$  is distributed during March and September, and  $I^{131}$  during January and June. These new standards bring to a total of nine the number of radioactive standards distributed or calibrated by the Bureau.

The radioactive isotopes  $P^{32}$  and  $I^{131}$  have been employed extensively for diagnosis and therapy in brain surgery, leukemia and other types of cancer. In the early use of these "tagged" atoms, variations in the results obtained by different laboratories amounted to as much as 100 and 200 percent of the accepted value. It is primarily for this reason that the Bureau has extended its efforts toward standardization. The procedure that has been established will now permit the duplication of research results at different laboratories and installations.

The  $P^{32}$  and  $I^{131}$  standards consist of a flame-sealed sterilized glass ampoule containing the active isotope in approximately 3 milliliters of dilute carrier solution. The exact disintegration rate per milliliter as of the zero date is noted and is roughly 100,000 disintegrations per second per milliliter (dps/ml). These standards, because of their low activity, are exempt from Federal regulations regarding the possession, use, and transfer of radioactive materials.

The NBS solution standards can be obtained by writing at any time to the Radioactivity Section, National Bureau of Standards, Washington 25, D. C., or by completing an order form that is circularized in advance of the distribution. All requests received will be filled at the nearest distribution date. The fee for this service is \$5.00. Remittances should be made payable to the National Bureau of Standards. Federal and State agencies are exempt from payment. In addition, a very limited supply of  $I^{131}$  and  $P^{32}$  solution standards will be

kept on hand at all times for immediate distribution to laboratories for emergency purposes only.

Other radioactive standards available from NBS include radium-gamma-ray solution standards; radium solution for radon calibrations; radium D+E beta-ray standards; calibrated radioactive-ore samples; cobalt-60 beta- and gamma-ray solution standards; carbon-14 beta-ray solution standards; and neutron-flux standards.

## Society Meetings

### International Union of Chemistry

The International Union of Pure and Applied Chemistry held the closing sessions of its 16th Conference in Washington, D. C., on September 14 and 15 in honor of the National Bureau of Standards Semicentennial. The earlier sessions were held in New York. Members of the Union devoted the afternoon and evening of September 14 to tours of the NBS laboratories and to participation in a dinner celebrating the Bureau's 50th anniversary. Dr. Detlev W. Bronk, President of the National Academy of Sciences, presided at the dinner. The speakers were Secretary of Commerce Charles Sawyer, who spoke on "The new realism"; Professor H. R. Kruyt, retiring president of the International Union; Dr. E. U. Condon, NBS Director; and Dr. William A. Noyes, Jr., Chairman of the Division of Chemistry and Chemical Technology of the National Research Council. Ambassadors and Ministers from many of the countries adhering to the Union were present as guests of honor.

The Union, an organization representing some 30 countries, was formed shortly after the First World War to promote international agreements in the field of chemistry. Since its founding the Union has held conferences regularly at 2-year intervals, except during the period of the Second World War. The only previous Conference held in the United States was in 1926.

The Union functions primarily through commissions of experts, who are chosen mainly because of their interest and competence in a particular subject, but also with regard to their geographical distribution. The functions of the commissions may be illustrated by the three commissions on chemical nomenclature, which deal respectively with standardization of the names of substances in the fields of organic, inorganic, and biological chemistry. Agreement on the names of chemical substances, many of them very complex, not only promotes the ready understanding of the chemical literature published in various languages but facilitates international trade in chemical products. Another commission, of which Dr. Edward Wichers (Chief of the NBS Chemistry Division) is chairman, deals with atomic weights and is responsible for international agreement on these important chemical constants.

Several other members of the chemical staff of NBS are members of commissions of the Union and participate actively in its work. There is a close similarity between the Bureau's efforts toward chemical standardization on a national scale and the international

standardization sought by the Union. The recent meetings, which were attended by about 250 foreign chemists, did much to acquaint the NBS staff with work going on abroad and to promote the fundamental objectives on the National Bureau of Standards and of the International Union.

There are altogether more than 20 commissions with several new ones in process of organization. The commissions are organized in six groups, under the sections of physical chemistry, inorganic chemistry, organic chemistry, analytical chemistry, biological chemistry, and applied chemistry. Each section has officers and an executive commission and enjoys a considerable degree of autonomy. The actions of the commissions and sections are subject to ratification by the Union's Council, which is composed of delegates appointed by the member countries.

At intervals the Union sponsors International Congresses of Chemistry, as the one held in New York on September 10 to 13 and attended by representatives of 36 countries. More than 6,000 chemists heard a program of nearly 1,000 papers, over one-third of which were presented by authors from abroad. The Congress, together with the Diamond Jubilee Meeting of the American Chemical Society earlier in the month, at which about 10,000 chemists were present, represented the greatest gathering of chemists ever assembled.

### Illuminating Engineering Society

The Illuminating Engineering Society held its annual National Technical Conference in Washington on August 27 to 30. Approximately 800 members of the Society attended the conference, which was designed to bring lighting engineers up to date on new developments in the field of illumination.

Dr. Wallace R. Brode, Associate Director of the National Bureau of Standards, addressed the opening session of the conference on those phases of the NBS program that are of vital concern to the Illuminating Engineering Society; namely, work in the fields of photometry, colorimetry, spectrophotometry, and radiometry. In tribute to the Bureau's accomplishments during the past 50 years in illuminating engineering and allied sciences, the Society presented NBS with a scroll. Mr. Walter Sturrock, President of IES, made the presentation to Dr. Brode, who accepted on behalf of the staff.

Forty-seven technical papers were included on the program. These covered such fields as new and improved light sources, lighting economics, glare and comfort, military and defense lighting, aviation lighting, street lighting, residence lighting, and photometric testing of fluorescent fixtures. Dr. Deane B. Judd (NBS) presented a paper prepared jointly with Dr. Harry Helson and Martha H. Warren of Brooklyn College, on "Object-color changes from daylight to incandescent filament illumination".

The Annual Progress Report of the Society described new materials and developments made during the past year in lighting. New types of lighting sources and fixtures were demonstrated, and unique lighting in-

stallations and applications were shown by lantern slides. Among the slides were those showing improvements in the lighting of the Shrine where the Declaration of Independence and the Constitution are displayed at the Library of Congress. This new installation was designed by Ray P. Teele of NBS.

In conjunction with the IES meetings, the Society's Committee on Aviation Lighting held a conference at NBS where technical papers of special interest to aviation lighting engineers were presented. Following this, members of the Society toured NBS laboratories.

### Statistical Methods for Chemists

The basic information required by the laboratory scientist who wishes to make use of modern statistical techniques is given in a new 130-page book, *Statistical methods for chemists* (John Wiley and Sons, \$3.00), by Dr. W. J. Youden of the NBS statistical engineering laboratory. Written especially for those who make measurements and interpret experiments, rather than for the professional statistician, the book employs a practical approach characterized by an absence of statistical theory and proofs. Emphasis is placed on such knowledge as will enable the laboratory worker to interpret his data more intelligently, to judge better the validity of his results, and to design experiments in such a way as to obtain a maximum amount of reliable information from a given number of observations.

Statistical principles are illustrated with a number of actual numerical examples taken principally from the field of chemistry. The 10 chapters deal with precision and accuracy, measurement of precision, comparison of averages, resolution of errors, statistics of the straight line, analysis of variance, interaction between factors, requirements for data, arrangements for improving precision, and experiments with several factors. An appendix provides tables of squares, critical values of  $t$ , and critical values of  $F$ .

### Selection of Hearing Aids

To fill the need for a practical guide to proper choice of hearing aids, the National Bureau of Standards has published a Circular based on its studies of properties and performance of hearing aids. An individual must decide for himself which instrument is best for him. To help him make this selection, the Circular discusses the general nature of sound and the hearing process and outlines standards for judging hearing aids.

Hearing aid clinics located all over the country, as well as other organizations offering impartial help, are listed. They can give a person with defective hearing expert noncommercial advice and opportunity for trying various makes of hearing aids.

Circular 516, *Selection of hearing aids*, is available from the Government Printing Office, Washington 25, D. C., at 15 cents a copy. Foreign orders must include one-third the publication price to cover mailing costs.

# Publications of the National Bureau of Standards

## PERIODICALS

- Journal of Research of the National Bureau of Standards, volume **47**, number 4, October 1951 (RP2246 to RP2258, incl.)
- Journal of Research of the National Bureau of Standards, volume **46**, Title page, corrections, and contents, January to June 1951 (RP2167 to RP2219, incl.) 10 cents.
- Technical News Bulletin, volume **35**, number 10, October 1951. 10 cents.
- CRPL-D86. Basic Radio Propagation Predictions for January 1952. Three months in advance. Issued October 1951. 10 cents.

## RESEARCH PAPERS

*Reprints from Journal of Research, volume 47, No. 3, September 1951*

- RP2236. First dissociation constant of phosphoric acid from 0° to 60° C; limitations of the electromotive force method for moderately strong acids. Roger G. Bates. 10 cents.
- RP2237. Determination of ash in GR-S synthetic rubbers and latices. Frederic J. Linnig, Lewis T. Milliken, and Ralph I. Cohen. 10 cents.
- RP2238. Glass spheres for the measurement of the effective opening of testing sieves. Frank G. Carpenter and Victor R. Deitz. 10 cents.
- RP2239. Precise topography of optical surfaces. James B. Saunders. 10 cents.
- RP2240. The hydrodynamics of cathode film. Garbis H. Keulegan. 10 cents.
- RP2241. Absorption spectra of thioindigo dyes in benzene and chloroform. Wallace R. Brode and George M. Wyman. 10 cents.
- RP2242. A sinter-flow pyrometer for measuring gas temperatures. George T. Lalos. 10 cents.
- RP2243. Convergence of Cauchy-Riemann sums to Cauchy-Riemann integrals. Otto Szasz and John Todd. 10 cents.
- RP2244. Maximum likelihood estimates of position derived from measurements performed by hyperbolic instruments. Eugene Lukacs. 10 cents.
- RP2245. Infrared spectra of eighteen halogen-substituted methanes. Earle K. Plyler and W. S. Benedict. 15 cents.

## APPLIED MATHEMATICS SERIES

- AMS14. Tables of the exponential function  $e^x$ . Supersedes MT2. \$3.25.

## BUILDING MATERIALS AND STRUCTURES REPORTS

- BMS125. Stone exposure test wall. Daniel W. Kessler and R. E. Anderson. 30 cents.

## CIRCULARS

- C512. Methods of measuring humidity and testing hygrometers. Arnold Wexler and W. G. Brombacher. 15 cents.
- C513. Bibliography on the measurement of gas temperature. Paul D. Freeze. 15 cents.
- C516. Selection of hearing aids. Edith L. R. Corliss. 15 cents.

## HANDBOOKS

### (CORRECTION SHEETS)

- Correction sheets, changes adopted by the Thirty-sixth National Conference on Weights and Measures, 1951. (To supplement H44, *Specifications, tolerances, and regulations for commercial weighing and measuring devices*.) Available upon request from the National Bureau of Standards, Washington 25, D. C.

## MISCELLANEOUS

- M201. Hydraulic research in the United States. Helen K. Middleton and Sonya W. Matchett. \$1.25.

## PUBLICATIONS IN OTHER JOURNALS

- Electron-optical exploration of space charge in a cut-off magnetron. D. L. Reverdin. *J. App. Phys.* (57 East Fifty-fifth Street, New York 22, N. Y.) **22**, 257 (March 1951).
- Determination of grease in leather. E. W. Zimmerman and Eleanor F. Pangborn. *J. Am. Leather Chem. Assoc.* (Campus Station, Cincinnati, Ohio) **46**, 342 (June 1951).
- Second order determinants of Legendre polynomials. George E. Forsythe. *Duke Math. J.* (Duke University, Durham, N. C.) **18**, 361 (June 1951).
- Note on an infinite integral. Alexander M. Ostrowski. *Duke Math. J.* (Duke University, Durham, N. C.) **18**, 355 (June 1951).
- Recurrent determinants of Legendre and of ultraspherical polynomials. E. F. Beckenbach, W. Seidel, and Otto Szasz. *Duke Math. J.* (Duke University, Durham, N. C.) **18**, 1 (March 1951).
- A "Simpson's rule" for the numerical evaluation of Wiener's integrals in function space. R. H. Cameron. *Duke Math. J.* (Duke University, Durham, N. C.) **18**, 111 (March 1951).
- Effective earth's radius for radiowave propagation beyond the horizon. William Miller. *J. App. Phys.* (57 East Fifty-fifth Street, New York 22, N. Y.) **22**, 55 (January 1951).
- Fluctuations in the refractive index of the atmosphere at microwave frequencies. George Birnbaum. *Phys. Rev.* (57 East Fifty-fifth Street, New York 22, N. Y.) **82**, 110 (April 1, 1951).
- Textile Forschung und Prufung am National Bureau of Standards, Washington. Herbert F. Schiefer. *Sonderdruck aus Melliand Textilberichte* (Heidelberg, Germany) **32**, 125, 188 (1951).
- Machine methods for finding characteristic roots of a matrix. Franz L. Alt. *Proceedings, Computation Seminar, December 1949* (IBM, 590 Madison Avenue, New York 22, N. Y.) p. 49.
- The relation between the absorption spectra and the chemical constitution of dyes. XXII. *cis-trans* isomerism in thioindigo dyes. George M. Wyman and Wallace R. Brode. *J. Am. Chem. Soc.* (1155 Sixteenth Street, NW, Washington 6, D. C.) **73**, 1487 (1951).
- Some statistical designs for experiments. George Warren. *Proc. 12th Annual Porcelain Enamel Inst. Forum* (Porcelain Enamel Inst., Inc., 1010 Vermont Avenue, NW, Washington 5, D. C.) p. 76 (1950).
- Air replaces sand in "no-fines" concrete. Rudolph C. Valore, Jr., and William C. Green. *J. Am. Concrete Inst.* (18263 W. McNichols Rd., Detroit 19, Mich.) **22**, No. 10, 833 (June 1951) Title No. 47-55.
- Certain Fourier transforms of distributions. E. Lukacs and O. Szasz. *Canadian J. Math.* (University of Toronto, Toronto, Ontario) **3**, No. 2, 140 (1951).
- Pyrolysis of mixtures of ethane and ethane- $d_6$ . Leo A. Wall and Walter J. Moore. *J. Am. Chem. Soc.* (1155 Sixteenth Street NW, Washington 6, D. C.) **73**, 2840 (1951).
- Boron needs well-made steel plus intelligent heat treatment: Part of a panel discussion on "Saving precious alloys by intelligent use of alternatives". T. G. Digges. *Metal Progress* (7301 Euclid Avenue, Cleveland 3, Ohio) **59**, 823 (1951).
- Developing seals for abrasive-fluid mixtures. J. Rabinow. *Machine Design* (Penton Building, Cleveland 13, Ohio) **23**, 128 (June 1951).
- NRL Aleutian radio eclipse expedition. John P. Hagen and Fred T. Haddock (Naval Research Laboratory), and Grote Reber. *Sky and Telescope* (Harvard College Observatory, Cambridge 38, Mass.) **10**, 111 (March 1951).

*Publications for which a price is indicated are available only from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. (Foreign postage, one-third additional). Reprints from outside journals are not available from the National Bureau of Standards, but can often be obtained from the publishers.*

